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ORIGINAL MEMOIRS.

FILARIASIS.

BY JOHN H. CUNNINGHAM, JR., M.D.,

OF BOSTON,

Surgeon to the Long Island Hospital, Boston, Mass.

FILARIASIS is an endemic parasitic disease of surgical interest because of certain local manifestations produced by the parasites in the lymphatic system which may be benefited by surgical measures.

Manson, whose work upon this subject has extended over a period of twenty years, states that there are four well-known nematodes which inhabit the circulation, and that there are probably other species. He gives the following nomenclature: The original filarial embryos, described by Lewis, are the ones which concern us here, and have been given the name *Filaria nocturna*. The other filariæ he has termed *Filaria diurna*, *Filaria perstans*, and *Filaria Demarquaii*. Two doubtful species he gives the names of *Filaria Ozzardi* and *Filaria Magalhæsi*. Prout has recently described another blood-worm under the name of *Filaria gigas*.

No pathological importance is attributed to any of these parasites except to the *filaria nocturna*, which is the embryonic form of the adult worm *Filaria Bancrofti*, whose natural habitat is the lymphatic system of man.

Filarial disease occurs endemically in tropical and sub-tropical countries, and is prone to exist along the seacoast and large rivers. The origin of the sporadic cases, occasionally encountered in the colder climates, can usually be traced to one of the following geographical regions: India, Ceylon, China, the Malay Archipelago, Japan (particularly the most southerly islands), Egypt, East Africa (especially along the coast of Zanzibar), Mombasa and Tanga, the West Coast of Africa, Senegambia, Madagascar, and Orange River Colony (Bloemfontein), Reunion, Mauritius, Australia (Queensland), New Caledonia, the South Sea Islands, Guiana, Brazil, United States of Colombia, West Indies, and Spain.

In the filarial districts a large proportion of the population is affected by the disease. In Amoy (China) Manson found one-eighth of the population affected. Thorpe found twenty-five per cent. of the natives of the Fiji Islands affected, and thirty-two per cent. of the Friendly Islands. In southern India, in the districts of Travancore and Cochin, Underwood reports one-tenth of the whole population as afflicted. Koniger states that fifty per cent. of the male population of Samoa have filariasis. According to Saville seven-tenths of the adult males of the island of Huahine, one of the Friendly group, suffer from the disease.

Vincent tabulates five hundred cases taken indiscriminately from among patients at the Colonial Hospital, Port of Spain, and St. Anne's Lunatic Asylum, and from private sources. The percentage of blacks with filariasis was 4.9, of whites 10.9, and of East Indians 2.4. The percentage of infection in the case of the whites is strikingly high. The white population of Barbadoes and Demarara show a high percentage of infection, and in Trinidad, 14.5 per cent. of the white population are infected with this disease.

Indigenous cases in the southern part of the United States are on record. De Saussure, in 1890, reported twenty-two cases that he had observed in Charleston, S. C. Slaughter, in 1891, reported two indigenous cases in the northern part of Virginia. Mastin, in 1888, found such a case in Mobile, Ala.,

and Dunn has demonstrated filaria embryos in a woman who has always lived in Pennsylvania. Guiteras, in 1886, called attention to the presence of the disease in the southern states, four in Key West and one in Charleston, S. C. Cases occurring in the seaport towns can be explained by the constant communication with the filarial districts, but the origin of the indigenous cases is more difficult to understand.

The following case, a native of the United States of Colombia, was referred to me by Dr. C. H. Le Franc, of Cartagena, in May, 1904:

D. M., 35, M. Merchant; Spaniard; South American born.
Family History.—Excellent.

Past History.—No severe illnesses. Gonorrhœa three times, last attack twelve years ago. No complications or sequelæ.

Present Illness.—In 1885 the patient had a severe attack of "chills and fever" which confined him in bed for two days. Associated with the fever there was moderate swelling of the scrotum and severe pain in the lumbar region. Nothing abnormal regarding the urine was noted. The "chills and fever" ceased in a few days, but the swelling of the scrotum persisted in slight degree. There was a similar attack once every year until 1892, when the pain in the back was much more severe and the urine became bloody. The scrotum at this time was the size of a coconut, and bunches, the size of the fist, appeared in each inguinal region. The "chills and fever" continued about four weeks, during which time the patient was confined to bed. As the "chills and fever" subsided, the swelling in the scrotum disappeared, and those in the groin diminished in great part. Diarrhœa was profuse at this time. The hæmaturia continued for three months. During this attack of hæmaturia he came to Boston and saw Dr. Arthur Cabot, who found filarial embryos in his blood.

The attack the following year, 1893, was less severe and he had no associated hæmaturia or diarrhœa, although the scrotum was abnormally large and the tumors in the inguinal region became enormously swollen. In 1894 there was again hæmaturia lasting one month. The pain in the back was severe at this time.

These attacks of chills and fever and swelling of the scrotum

without further hæmaturia occurred once yearly until 1902, during which year he had three attacks of the same character already noted, associated with severe diarrhœa. At no time did the patient pass chylous urine. There was no frequency of urination, or difficulty or pain in performing the act except during the attacks of hæmaturia, at which time the passage of small blood-clots caused considerable pain.

The scrotum has remained swollen between the attacks, and there has been considerable pain in the region. There has also been constant dull lumbar pain. The scrotal pain was constant, of a dull, heavy dragging character, and was aggravated by walking or riding, and for which he has worn a supporter since 1892. It has been necessary for him to give up horseback riding for the last few years, on account of pain of a severe, sickening character radiating from the perineum into the epigastrium, causing him to become nauseated.

The patient states that he has suffered from melancholia for the past seven years, but there is no definite history pointing to this mental disturbance.

Dr. Le Franc states that when the scrotum and inguinal regions were acutely enlarged he believed there was fluid in the tunica vaginalis. The swellings subsided with the application of hot fomentations.

Physical Examination.—Well developed and nourished. Dark complexioned. Heart and lungs normal. Abdomen full, lax, tympanitic, not tender. Liver area normal, not felt. Spleen not felt; area not increased. Neither kidney palpable. Fulness throughout the course of both inguinal canals, producing an elongated swelling slightly more on the right than left, about one inch high and two inches wide, extending from the scrotum to the internal abdominal ring. These swellings are firm, but not hard, tender, or movable. They are deeply situated and continue into the scrotum along the spermatic cord. The scrotum is enlarged downward and laterally and appears distended by masses within. It is slightly fuller on the right than on the left side. Palpation shows a mass somewhat larger than the fist in the right upper quadrant; it is continuous with the mass in the right inguinal region and resembles a varicocele to the touch. This is continued downward along the course of the spermatic cord.

The vas deferens is clearly defined posteriorly. The right testicle is displaced into the perineum about one inch below the scrotum, and perineal junction. It is easily replaced into the scrotum, but drops back immediately when not held.

A similar but smaller mass is present in the left upper quadrant of the scrotum, which also continues downward along the spermatic cord, from which it is easily differentiated posteriorly. The cord on this side is slightly lengthened and presents the same character as that on the other side, and the testicle, which like its mate is normal in size and shape, is situated a little lower than normally.

The external inguinal ring on both sides, although only admitting the tip of the index-finger, because of continuation of the masses already noted into the inguinal canals, are considerably enlarged. There is no impulse or expansion of the masses on cough.

The skin of the scrotum is not thickened nor otherwise abnormal in character. No fluid is demonstrable in the tunica vaginalis, either by palpation or by the hydroscope. The cremasteric reflexes are equal and lively. The scrotum is diminished about one-third in size when the patient is lying flat. It is also diminished by the application of cold. The urethra admits a 27 *bougie à boule* to the triangular ligament and no obstruction is met in withdrawing it. The sound, 27 F., is passed into the bladder without meeting obstruction or deviating from a median line.

The *rectal examination* shows the prostate to be normal in size, shape and contour, with a distinct median raphe. Both seminal vesicles are normal by palpation.

Extremities normal. Reflexes equal and lively. No general or local glandular enlargement.

Urine Examination.—Color normal; sp. gr. 1014; acid; no albumin, bile or sugar; urea 2.8; cryoscopic freezing point 2.1; no apparent sediment. Centrifugalized urine shows no cells or casts. Occasional normal blood-corpuscles. A few sodium urate crystals. No embryo filaria found in many examinations at different times of day and night.

Blood Examination.—The blood examinations at different times are as follows:

May 12, 1904 (3 P.M.).—White cells, 5,200. Red cells, 5,640,000. Hgb. 90 per cent. No filariæ.

Differential count of 100 cells:

Lymphocytes	38.
Mononuclear leucocytes	4.
Polynuclear leucocytes, ...	51.5
Eosinophiles	6.5

May 14, 1904 (4 P.M.).—White cells, 5,600. Red cells, 5,600,000. Hgb., 90 per cent. No filariæ.

Differential count of 100 cells:

Lymphocytes	36.
Mononuclear leucocytes	6.
Polynuclear leucocytes	50.5
Eosinophiles	7.5

(12 Midnight).—White cells, 11,5000. Red cells, 5,102,000. Hgb., 90 per cent. Many filariæ.

Differential count of 100 cells:

Lymphocytes	40.
Mononuclear leucocytes	6.
Polynuclear leucocytes	35.5
Eosinophiles	18.5

May 16, 1904 (3 P.M.).—White cells, 5,4000. Red cells, 5,120,000. Hgb., 95 per cent. No filariæ.

Differential count of 100 cells:

Lymphocytes	30.
Mononuclear leucocytes	4.5
Polynuclear leucocytes	60.
Eosinophiles	5.5

(11 P.M.).—Many filariæ.

Differential count of 100 cells:

Lymphocytes	45.
Mononuclear leucocytes	4.5
Polynuclear leucocytes	31.5
Eosinophiles	19.

May 18, 1904 (3 P.M.).—Examination by Dr. Pratt:

Erythrocytes	5,504,000
Hæmaglobin	100 per cent. (Sahli).
No leucocytosis	

Differential count of Leucocytes	Percentage.
Eosinophiles	7.1
Polynuclear leucocytes	52.2
Lymphocytes	37.
Large mononuclear leucocytes	3.3
Mast cells	.4
	100.0

292 leucocytes counted.

(12 Midnight).—White cells, 12,600. Many filariæ.

Differential count:

Lymphocytes	36.
Mononuclear leucocytes	6.
Polynuclear leucocytes	37.5
Eosinophiles	20.5

June 7, 1904 (11 P.M. 18 days after operation).—White cells, 5,000. Red cells, 5,280,000. Hgb., 100 per cent. No filariæ found.

Differential count:

Lymphocytes	28.
Mononuclear leucocytes	4.5
Polynuclear leucocytes	62.5
Eosinophiles	5.

Patient was seen in consultation by Dr. Abner Post and Dr. Joseph H. Pratt.

Operation.—May 20, 1904. Ether. Incisions about eight inches long, extending from the internal abdominal ring downward over the anterior surface of the scrotum along the course of the spermatic cord. The masses previously noted were found to be enormously enlarged lymphatics, and to a less extent dilated veins of the spermatic cord. As these continued into the inguinal canal, the fascia of the external oblique muscle was incised up to the internal abdominal rings. The vas deferens on both sides were dissected from the enormously dilated lymphatics, leaving a small amount of adjacent tissue for blood supply. The testicles, normal in every respect, were left attached to the vas of their respective sides. The cords, however, were ligated at a point about three-quarters of an inch above the epididymis. A clamp was applied about one centimeter above the tie and the cord cut between, with a small escape of chylous fluid, which was caught on swabs for examination. The masses were somewhat diminished in size as they disappeared into the abdomen through the

internal abdominal rings. These were transfixed at this point and tied. The mass was clamped just below the tie and cut between, with an escape of chylous fluid as before.

The testicles were then attached, by a mattress suture passed through the cut end of the cord, to a septum of the scrotum on either side, so that they assumed a normal position. The vas deferens on each side was placed in its normal position in the inguinal canal and the fascia of the external oblique muscle was sutured by continuous chromic gut sutures. The superficial fascia was sewn in a like manner, and the external wound brought together by silkworm-gut sutures, while the scrotum wound was sewn by continuous chromic gut. A dry sterile dressing and a T-bandage were applied, with the scrotum elevated. Duration of operation one and one-half hours.

The patient took ether badly throughout the operation, frequently hiccupping. About fifteen minutes after being removed from the table the patient, although having had a pulse of about 110 throughout the operation, was found to be pulseless. Strychnia, one-thirtieth of a grain, was given subcutaneously. Heaters, blankets and elevation of the foot of the bed failed to produce a pulse of such a character that it could be counted. The patient was given three shock enemas consisting of coffee, brandy, and salt solution, at intervals of one-half hour. These did not materially improve his condition.

His skin and mucous membrane were blanched, and as he came out of the ether he was very restless, desired to be fanned, was very thirsty and complained of a sense of oppression. This, together with a barely perceptible pulse, pointed strongly toward hæmorrhage. Examination of the wound two hours after operation failed to reveal anything other than a slight ooze. Percussion of the abdomen gave no signs of internal hæmorrhage except for dulness in the left flank, which did not move with change of position, and which might well have been the retained shock enemas.

The patient was given fifteen minims of tincture digitalis intra-muscularly every three hours, and received one litre of normal saline solution under the breast, about two and one-half hours following operation. The condition certainly suggested internal hæmorrhage, and, although special care was taken in

tying off the spermatic cord, it was feared that bleeding was taking place from one of these stumps. However, operative interference was absolutely contraindicated on account of the patient's low condition. At the end of eight hours his condition remained practically the same, which fact, together with the knowledge of his condition immediately following operation, pointed less strongly toward hæmorrhage, the classical and technical signs of which still remained.

He was blanched and restless. Respiration 60 a minute. Temperature, 94°. Semi-conscious, feebly requesting water and air. Ten hours following operation the pulse became of slightly better quality, although it was still too rapid to be counted. From this time on his pulse gradually improved in quality, and the following day ranged between 150 and 160, but was decidedly thready in character. Forty-eight hours following operation the pulse had reached 120 and was of better quality; the temperature had jumped to 100.5°, and his general condition was fair, although he still remained blanched.

The patient improved slowly from this time, and one week following the operation the pulse was 80, of good volume and tension, and the respirations and temperature were normal.

The wounds healed by first intention and the stitches were all removed on the tenth day. The patient was up on the twentieth day following operation, and was discharged from the hospital June 9, 1904.

The blood was examined several times for filariæ beginning twelve days after operation, but none were found.

The day following discharge from the hospital the patient noticed a small swelling in the upper part of the left wound. It was not tender and presented none of the signs of inflammation except a slight sense of fluctuation. A small incision was made into the mass, and about a half dram of a greyish gelatinous substance was obtained. Under the microscope this substance was found to be necrotic tissue. No evidence of a suture could be found, and nothing resembling any part of an adult filaria was seen. The wound was dressed twice daily for six days, at the end of which time only a slight granulating area remained, and the patient returned to South America.

Word occasionally received from Dr. Le Franc informs me

that the patient has had no return of his symptoms, and that the embryos remain absent from the blood. On September 27, 1905, Dr. Le Franc stated that the patient had become the father of a child and that he had expressed himself as being much improved sexually since the operation.

In a letter received from the patient himself in January, 1906, twenty months after operation, he states that he considers himself entirely cured of his trouble.

The Specimen.—The mass of tissue removed from the *right side* is 24 cm. long. The lower end shows several small vessels cut across. The diameter at this point is 2 cm. The upper end, similar in structure, measures 2 cm. in diameter. From both ends the mass increases in size and the central point is ovoid in shape. This enlarged area measures 12 cm. x 6 cm. x 3 cm., and is made up of tortuous vessels from 1 to 5 mm. in diameter, resembling a varicocele. These vessels are surrounded by loose areolar tissue. The contents of these vessels is chylous.

The specimen from the *left side* is 21 cm. long and 4 cm. at its greatest width. Like the specimen of the right side, it consists of tortuous lymphatic vessels and areolar tissue, and two of the vessels can be traced the entire length of the mass. They measure 7 mm. in diameter, and the walls are 1 mm. in thickness.

The tissue was placed in normal salt solution and kept in a thermostat for several hours, but the worms did not appear.

The two masses of tissue were examined microscopically by Dr. S. B. Wolbach, of the Harvard Medical School. The tissue was divided into slices, about 1 cm. thick. Every other slice was embedded in celloidin, and stained with hæmatoxylin and eosin. Twenty-eight blocks in all were examined.

The microscopic sections consisted of loose connective and fat tissue, with many thick-walled arteries and veins, some of which are obliterated by connective tissue. There is a marked lymphoid and plasma-cell infiltration in the connective tissue surrounding the capillaries and veins. There are numerous dilated lymphatics in the fat and perivascular tissue. There is a slight general infiltration of the connective tissue with lymphoid and plasma cells. No filariæ were found in the tissue examined.

It has been suggested by Dr. Wolbach that the worms may have escaped with the chyle which was emptied from the lymphatic directly after the operation.

History.—Certain manifestations due to the *filaria sanguinis hominis* received the attention of Arabian medical men as far back as the ninth and tenth centuries. The chief manifestation of which we have record was elephantiasis, which is the Greek translation of the words Da-al fil, meaning elephantine disease.

Chapotin, in 1812, had recognized endemic hæmato-chyluria and communicated his knowledge in writing to Mauritius.

Nothing was known of the etiological factor producing these various manifestations until 1863, when Demarquay, in Paris, first discovered the *filaria nocturna* in a chylous fluid obtained by tapping a hydrocele in a young man, a native of Havana.

In 1868, Wucherer, in Bahia, Brazil, found filarial embryos in chylous urine.

In 1868, Lewis, in Calcutta, also observed filarial embryos in chylous urine, and demonstrated them in the blood of a patient with chronic diarrhœa. He subsequently found the parasites in the blood and lymphatic secretions of individuals with elephantiasis of the legs and scrotum, and in the blood of persons presenting the symptom hæmaturia, and considered the parasite to be the cause of these various manifestations. Lewis demonstrated the *filaria* without any knowledge of the previous discoveries, and gave the hæmatozoon the name of *filaria sanguinis hominis*.

It had been observed that the filari did not grow to the adult worm in the human body. In 1878 Manson discovered that the mosquito was the intermediate host in which the embryo matured to the adult worm and then invaded man anew. He found that the *filaria* embryos were ingested with the blood by the female mosquito (the male having no sting), and were developed in the stomach. Some of the embryos were digested, others slipped from their sheaths and bored through the walls of the stomach, invading the muscles of the thorax, undergoing a metamorphosis, requiring two or three weeks until they were transformed into an actively mobile

worm. He believed that matured eggs were deposited in stagnant water and that the filaria entered the human body in drinking water.

Bancroft found that the larvæ could not live in water, dying in from three to four days. His idea was that infection occurred by swallowing mosquitoes containing larvæ while asleep, with food, or the mosquito being killed, the filaria was transferred to the mouth by means of the fingers. He also believed in the transmission of the disease through the sting of mosquitoes.

Myers, to determine the truth of Manson's idea, fed monkeys with water in which mosquitoes fed upon the blood of filarial patients had laid their eggs. The results were negative.

Vincent, in 1895, proved by careful experiments that when the mosquito falls into the water, the filariæ, if unable to escape, die in twenty-four hours by imbibition, and in another series proves that the filaria does not pass from the living mosquito in the act of suction of water.

Lewis confirmed Manson's observations that the filaria larvæ pierced the walls of the mosquito's stomach and experienced developmental changes in the abdominal and thoracic tissue. Low demonstrated that the filariæ migrated to the head and proboscis of the mosquito and inferred that the parasite enters human tissue when the insect stings an individual.

Manson deserves the credit for our knowledge of the *life history and periodicity* of the parasite. He demonstrated that the embryos were present in the peripheral circulation during the night, and considered this periodicity to be an adaptation to the habits of the mosquito.

Mackenzie pointed out that if the patient slept by day and worked by night the habit of the filariæ reversed and they were present in the peripheral circulation during the day and not during the night. His observations were made by examining the blood every three hours during the day and night for a period of ten weeks.

The periodicity cannot depend entirely upon the sleeping state, as the embryos can be demonstrated between five and six

o'clock or several hours before the patient retires. The number in the peripheral circulation increases, reaching a maximum about midnight, when from 300 to 600 are found in every drop of blood, which, assuming that the parasites are evenly distributed throughout the circulation, shows that there are from forty to fifty millions in the circulation at that time. The number gradually decreases from midnight, and they usually disappear entirely by eight or nine o'clock in the morning.

It is evident, therefore, that the sleeping state is not the cause *per se* of the increase in the number of parasites in circulation. The ingress begins several hours before the usual time for sleep and the egress is not complete until several hours after the usual time for waking. Further study may reveal a reasonable explanation for filarial periodicity.

In 1899 Manson demonstrated that when the filariæ are absent from the peripheral circulation they may be found in the larger blood-vessels of the lungs, and less frequently elsewhere. His observation was made upon a patient suffering from lymphscrotum and varicose inguinal nodes. This patient committed suicide in the morning by swallowing hydrocyanic acid, death occurring almost instantly. A post-mortem examination six hours later revealed a large lymphatic varix occupying the pelvis and the back part of the abdominal cavity. In this varix, adult filariæ Bancrofti were found. The embryos were noted to be most numerous in the large blood-vessels and in the lungs. They were also found in the liver, spleen, and heart muscles.

The Adult Filaria Bancrofti.—The adult filaria Bancrofti belongs to the nematodes, and was first discovered by Bancroft, of Brisbane, Australia, in 1876, in a lymphatic abscess on a patient's arm. In 1877 Cobbold published the fact and named the nematode the filaria Bancrofti.

The adult filaria, first found by Bancroft in 1878, has since been found by various observers. The adult filaria, however, has been found only in a very small percentage of the cases suffering from filariasis. In 1877 Lewis found a portion of a male and female worm in a blood-clot from a

lymphscrotum, after searching eight hours. In 1877 Des Santos, in Brazil, found five adult females in a lymphatic abscess of the arm. In 1881 Manson found a few fragments of a female worm in an abscess of the thigh, and in the same year demonstrated a female filaria in the dilated lymphatic in a case of lymphscrotum. In 1888 Sibthorpe of Madras, India, found two worms, a male and a female, on the cut surface of a lymphscrotum. In 1894 Maitland, of Madras, India, obtained eight adult worms in lymphatic tissue removed from the inner surface of the upper arm in two operations; three were males and five females. Huber states that Czerny found a living female filaria in the ovary of a woman from Rio Janeiro. In 1897 Young, in London, removed a hard, nodular mass from a sailor, a native of Jamaica, who suffered from lymphscrotum, and varicose groin glands. This man committed suicide, and at autopsy the right varicose groin-glands were found to contain three female filaria Bancrofti. In the lymphatics of the right spermatic cord six more adult female worms were found. In the left spermatic cord seven worms were found, one being a male. In 1890 Lothrop and Pratt found nine worms, two males and seven females, in the lymphatics of the epididymis, following castration for filariasis. In 1903 Opie found an adult worm in the right epididymis, at autopsy. Primrose, in 1903, obtained an adult filaria and several fragments in an operation for lymphscrotum.

Taniguchi records four cases in which the adult worms were found. One case was a male suffering from inguinal lymphvarices. Two adult worms were recovered at operation. His other case was a woman who had several small nodes in the breast. At operation several adult filariæ Bancrofti were found. The remaining two cases recorded by Taniguchi belonged, one to Ikeda, and the other to Kumono. Both these cases were operated upon for inguinal lymphvarices and lymphscrotum and the worms were found in each instance. The number and sexes are not recorded.

It is seen, from the above, that the female is much more commonly found than the male worm, and that the location

in fifteen out of the nineteen cases was in relation to some part of the generative system: Lymphoscrotum (Lewis, Manson, Bibthorpe, Primrose, Taniguchi, Ikeda, Kumono), chylocele fluid (Bancroft), epididymis (Lothrop and Pratt, Opie), ovary (Czerny), spermatic cord (Young), arm (Bancroft, Maitland, Young, and dos Santos), leg (Manson), breast (Taniguchi).

The adult parental forms of the filaria Bancrofti are long, hair-like, transparent nematodes, from three to four inches in length. The male and female are often found coiled about one another, within dilated lymphatics and the lymphatic glands themselves.

The female is considerably larger than the male, and measures from 8.5 to 9.5 cm. in length, and is the thickness of a human hair. Macroscopically the worm is a small, slender, delicate, whitish, hair-like body. Microscopically the head is rounded, with an unprotected oral orifice. The tail, which is slightly tapering, has an abrupt end. The anal aperture is situated just in front of the termination of the tail, while the sexual openings are near the head. The digestive tract is a simple tube, and the remainder of the body is occupied by the sexual organs. Manson states that the worm is normally viviparous, but that the eggs are sometimes prematurely deposited so that it becomes oviparous.

The male worm is shorter and slenderer and has a marked disposition to curl. Daniels gives his length as 4.4 cm. Manson describes two slender unequal spicules originating at the cloaca.

Embryos.—The embryos are found in the peripheral circulation as delicate, translucent, smooth, almost cylindrical bodies. The head end is rounded and the caudal extremity is pointed. Scheube states the average length to be 0.216 mm. and the breadth 0.004 mm. The parasite is enveloped in a transparent sheath which is longer than the embryo, and which is sometimes seen trailing after the head or tail, or both. The embryo has been observed to move about within its sheath. When studied in freshly-drawn blood the movements are con-

tinuous, but not those of progression. The tail whips from side to side actively amongst the blood corpuscles. It writhes and coils with much activity. The embryos remain alive for several days if the preparation is prevented from disintegration.

Under high magnification there is an irregular granular mass observed at the posterior part of the middle third of the parasite, and a very delicate transverse striation can be detected throughout the entire length of the embryo. By staining with a mild solution of hæmatoxylin Manson has demonstrated a V-shaped patch at a point of about one-fifth the entire length of the organism, backward from the head end, and a similar spot, though smaller, situated a short distance from the end of the tail. The former of these he terms the "V spot" and the latter the "tail spot," and considers them to be connected with development, the anterior one being the future water vascular system, or generative organs, and the posterior one for the anus or cloaca. Manson has also found in filarial embryos whose movements have almost ceased that the head is constantly being uncovered from a very delicate prepucce, and can sometimes demonstrate that a short fang is shot out and retracted from the center of the head.

The Life History of the Filaria Nocturna.—The mosquito is the intermediate host, and man the definite host. Female mosquitoes of the genus *Culex* (*C. fatigans*), and, according to James, *Anopheles* (*A. niggorimus*), draw the filarial embryos from the infested individual. The parasites find their way to the stomach, where they escape from their sheaths, which they leave behind. They penetrate the stomach and enter the thoracic muscles of the insect, where they undergo a metamorphosis, which, according to Manson, requires from sixteen to twenty days to complete. The embryo is then transformed into a worm a sixteenth of an inch long, with the activity of the young parasite. A mouth and alimentary canal, and a trilobed tail, may be distinguished. Less often these larval forms may be demonstrated in the abdomen as well as in the thorax. When this metamorphosis has taken place the majority pass forward by the prothorax and neck of the mos-

quito, and, as Low has pointed out, enter the proboscis. This observation has also been confirmed by Manson, Annette, Dutton, and James. Manson states that in all the sections of this region which he has examined he has found two worms together in each instance. The parasite remains in this position until the mosquito feeds upon some warm-blooded vertebrate, at which time the parasite enters the definitive host. Bancroft found that filarial infested mosquitoes, fed upon bananas or other vegetable substances, do not part with the filariæ situated in their probosces.

After entering the human body the filaria finds its way into the lymphatic system, where it remains and develops into the mature parent worm.

Pathological Changes Produced by the Presence of the Filaria Nocturna.—The presence of filaria in the human body does not always give rise to manifestations. In the majority of individuals afflicted, ill effects are produced by the obstruction of the lymphatics, and the greater proportion of such manifestations are associated with the generative and urinary systems; and furthermore, the parent worm is most often here located.

It is not known that the parent filaria lives elsewhere than in the lymphatic vessels in the human body, nor is there evidence that they migrate from one part of the body to another. It is not known how long the parent worms may remain alive, and persons living in filarial districts are probably infected many times.

No pathological changes are produced by the embryos, so far as is known. The parent worms, on the other hand, produce obstruction directly or indirectly in the lymphatic circulation. While it is rare that the worms produce occlusion of a lymph-channel, their presence results in secondary changes, thickening the lymphatic walls and narrowing their lumina. Moreover, the location of the parent worm is not infrequently the seat of infection, producing abscess and lymphangitis, which further changes the structure of the lymphatic channels. Manson states that the ova are capable

of obstructing the smaller lymphatics and stasis may be thus produced.

By thrombosing lymphatic channels there is a rise of lymph pressure in the occluded vessels resulting in varicosities and lymphatic œdema. As an effect a compensatory circulation is established.

Local Manifestations.—Great variation of the disease filariasis is displayed, dependent upon an engorgement of the lymphatics distal to the point of occlusion.

Flynn records fifty cases of filariasis, the clinical evidence occurring as follows: *Chyluria*, 9, 8 being males (one showed a palpable varicose condition of the prostate); *elephantiasis*, 7, 6 being females; *lymphscrotum*, 5; *chylous hydrocele*, 12; *intermittent orchitis*, 4; *varicose groin glands*, 13, all bilateral, and all in males.

The following changes are well recognized occurring singly or existing together: (1) Dilated lymph-vessels,—*lymphatic varix*, *lymphangiectasis*; (2) dilated lymph-glands,—*varicose glands*; (3) cutaneous lymphatic obstruction occurring as œdema,—*lymphscrotum*, *lymphvulva*, and *elephantiasis Arabum*; (4) rupture of dilated varices, producing chyluria, chylous hydrocele, chylous ascites, or chylous diarrhœa, according to the organ into which the rupture takes place; (5) manifestations produced by secondary pyogenic infection,—*lymphangitis*, *cellulitis* and *abscess*.

Dilated Lymph-Vessels. Lymphatic varix—lymphangiectasis.—By occlusion of the lymphatic channels there is a rise of lymph-pressure; the lymphatics distal to the obstruction become dilated, and a compensatory circulation is soon established, resulting in the formation of a lymphatic varix, varying in degree according to the amount of obstruction. The site of the obstruction, of course, varies the location of the varix. When the obstruction is in the thoracic duct, the chyle can only reach the circulation by a retrograde flow through the lymphatics of the groin, scrotum, pelvis, and abdomen. Dilatation therefore takes place in all the lymphatic vessels below the point of obstruction in the thoracic duct. Manson depicts a

case of Mackenzie's in which the abdominal and pelvic lymphatics formed a varix about a foot in diameter, concealing the kidneys, bladder and spermatic cords.

Opie reports the autopsy upon a case of *filaria sanguinis hominis* in which a plexus of enormously dilated lymphatic vessels was situated in the abdomen and pelvis, in front of the vertebral column. The plexus was continued along the whole course of the thoracic duct. From the plexus lymph varices extended along both spermatic veins as far as the epididymis, and a similar mass of dilated lymphatics was continuous along the course of the femoral artery and vein, and formed a mass in the groin. This mass was mistaken for a hernia at the patient's entrance to the Johns Hopkins Hospital, and was cut down upon, but not removed. The diagnosis of the true condition was not made until after death. Brodel's drawing of this case is the best illustration in literature.

Dilated Lymph-Glands (varicose glands).—It is unusual to observe varicose glands elsewhere than in the groins and femoral regions. Dilated lymphatic vessels can usually be demonstrated running to and from the nodes. The increase in size of the nodes is slow and usually without symptoms and they often attain a considerable size before they attract the patient's attention.

Upon inspection they resemble herniæ and unless they have been the seat of inflammation the skin is freely movable, the mass is soft, doughy, not tender, with an ill-defined outline. They decrease in size while the patient is in a recumbent position, and slowly enlarge when he is erect. The absence of impulse upon cough, tympany on percussion, and the demonstration of a normal sized external ring, may be the only features distinguishing it from inguinal hernia; and when situated in the femoral region the diagnosis is less easy.

The adult worms may have their seat somewhere in the thoracic duct, and the varicosities may be but a part of lymph varices existing in the abdomen and pelvis, as in Opie's case. On the other hand, the parasites may be situated in the groin-glands themselves. If a chylous fluid is obtained when the

lymph-glands are tapped, the obstruction is probably in the thoracic duct, but if the fluid is not milky, but clear, the parasite is probably contained within the mass.

Cutaneous Lymphatic Obstruction Occurring as Œdema.

—*Lymphscrotum* results from obstruction in the lymphatics of the skin and is usually accompanied by dilated lymph-glands. Small varices may appear on the scrotal integument. These sometimes rupture with the escape of lymph. Inflammation is prone to occur and ulcerations, cellulitis, or abscess formations may develop in the deeper layers of the skin, while eczema is often encountered upon the surface.

Lymphvulva does not differ in any way from lymph-scrotum.

Elephantiasis Arabum.—There has been some dispute as to whether this condition is a manifestation of filariasis. Manson, however, has recently presented evidence in support of this theory. This affection does not, however, concern us.

Rupture of Dilated Varices, producing *chyluria*, *chylous hydrocele*, *chylous ascites*, or *chylous diarrhæa*.—In the condition cited the parasites are probably located in the thoracic duct, or one of its affluents, or in the tissues about the abdominal aorta. Engorgement and a retrograde current in the dilated vessels results. The pressure within the vessels may be sufficient to cause them to burst. The viscus into which the rupture takes place becomes the site for the collection of the chylous fluid. If this occurs anywhere along the urinary tract a mixture of urine and chyle results. If the rupture takes place into the tunica vaginalis, it results in chylous hydrocele, or chylocele; the abdominal cavity, chylous ascites; and into the bowel, chylous diarrhæa.

Chyluria.—Although the presence of chylous urine comes on suddenly it is the commonest external manifestation of filariasis. The rupture of the dilated lymph-channel may take place anywhere along the urinary tract, most commonly in the bladder and kidney. The urine contains, besides its normal constituents, chyle and lymph. The color of the urine varies with the process of digestion. It is usually milk-white soon

after digestion has commenced, on account of the excess of fats. Because of the presence of the lymphatic contents when the process of digestion is not active, the urine is turbid when voided, and soon separated into three or more distinct layers.

Hæmorrhage may be associated with chyluria, when the condition is spoken of as *hæmatochyluria*. It is believed by some that the sanguinous character of the urine in *hæmatochyluria*, is due to the rupture of the blood-vessels at a point near the place of rupture of the lymphatic vessels. Manson, however, attributes the presence of blood in the urine, in such cases, to the formation of blood-corpuscles in the lymph contained within the varicose vessels.

The urine may suddenly become normal in color, probably from a closure of the fistula. There is a tendency for chyluria to recur, and Lancereaux records a case where it was persistent for fifty years.

Chyluria is found to occur after childbirth, or violent effort in those suffering from filariasis.

The site of the filaria Bancrofti in this condition has never been absolutely demonstrated. Ponfick and Havellburg each record a post-mortem, and Mackenzie has had two cases which came to autopsy, and in no instance were the parent worms found. Pain in the back is usually present, from the greatly distended lymph-varix within the abdominal cavity.

Retention of urine sometimes results by chylous coagulation in the bladder and is not infrequently the first indication of trouble in the urinary system.

Flynn has demonstrated a positive Widal reaction in one case. The test has not been applied to any other cases, so far as I am aware.

Chylous hydrocele is the result of chyle being poured out in the tunica vaginalis. In the case reported by Lothrop and Pratt the dilated lymphatics of the spermatic cord were excised. This prevented the normal return of lymph from the testes and an accumulation of chylous fluid resulted in the tunica vaginalis.

A chylous hydrocele presents the ordinary physical signs

of a serous hydrocele except that the translucency is diminished. The parent worms are usually situated in the region of the testicles.

Manson, recording sixty-two cases of filariasis, found six cases of chylous hydrocele. Flynn records twelve cases in a series of fifty, and has demonstrated quantities of cholesterol crystals in the fluid drawn from the tunica vaginalis. Embryos have been demonstrated in chylocele fluid by many.

Chylous ascites is dependent upon the escape of chyle from the abdominal lymphatics into the peritoneal cavity.

Chylous diarrhæa is the result of the emptying of the dilated lymphatic vessel into the intestinal canal.

(5) *Manifestations Produced by Secondary Pyogenic Infection.* *Abscess, lymphangitis and cellulitis.*—Whether or not on account of injury to the lymphatics by a blow or otherwise, the parent filaria sometimes dies, and acts as an irritant, producing inflammation, often resulting in abscess, in the contents of which fragments of the dead filaria have been found.

If the inflammation is within the abdomen the general abdominal symptoms dependent upon inflammation are evident.

Lymphangitis and *cellulitis* occur commonly in all forms of filarial disease, particularly in varicose glands, lymphscrotum, and elephantiasis. The lymphatic-trunks become cord-like, reddened, hot, and painful. The adjacent tissue and skin become inflamed and tense, and constitutional symptoms, ushered in by a prolonged rigor, with subsequent fever, continue for several days. Delirium and death may result. Usually, however, the attack is relieved by a discharge of lymph upon the surface of the skin, and a profuse general diaphoresis. This condition is spoken of as "elephantoid fever."

The Blood.—Filarial disease seems to exert little influence upon the red corpuscles or hæmoglobin. The white cells are however increased in number and there is a relatively high percentage of eosinophiles.

Gullard records a case in which the leucocytosis varied

from 4,600 to 13,500, and the eosinophiles between 3 and 12 per cent. In this case there was a constantly high proportion of lymphocytes, as well as eosinophiles, and the polynuclear forms never reached the normal minimum of 70 per cent. The most interesting point about Gullard's case is that the percentage of eosinophiles rose from a normal figure in the morning, when no filarial embryos were present, to a high percentage just before midnight, when a large number of embryos were in circulation.

Calvert found a leucocytosis and eosinophilia in two Filipino prisoners. He showed also that the percentage of lymphocytes was fairly high, and believes that filariasis, like trichinosis and akylostomiasis, has a positive chemiotaxis for eosinophiles, and that whenever the parasite is in the body there is an eosinophilia.

In one of Calvert's cases the leucocytosis reached 26,666, and in the other 14,000. The eosinophilia in the first case varied from 8. to 22., and in the second from 3. to 20.5.

He found the leucocytosis and eosinophilia to be most marked during the daytime, that is, when the embryos were not in the peripheral circulation.

Wherry and McDill found an eosinophilia varying from 6.0 to 10.0 in the morning, and 12.0 at midnight. Unlike Calvert's observations, they found the eosinophiles to be most numerous when the embryos occupied the peripheral circulation in the greatest numbers.

Wurtz and Clerc record an eosinophilia of 38.0, and in Lothrop's and Pratt's case the eosinophiles varied from 3.5 to 4.6.

Remlinger and Menchen Hodara-Bey record two cases of chyluria occurring in Egyptians. In these cases the eosinophilia was very high; in the first case 70.0, and in the second 75.0. They noted certain morphological changes in the eosinophiles. Each eosinophile presented very marked granulation in the protoplasm. Some leucocytes were observed, in which the granular material was outside of the cell, as though the cell-capsule had ruptured. They feel that the phagocytic

property of the leucocytes is diminished by this granular invasion and disintegration of the cells; and on this account suppurative processes are so common in filarial patients.

In the writer's case the blood observations show an increased number of leucocytes during the time at which the filarial embryos are in the peripheral circulation, and also a relatively high number of eosinophiles at this time. These observations are in accord with those of Gullard and those of Wherry and McDill. The lymphocytes remained constantly high, and were increased with the eosinophiles. There was little change in the mononuclear leucocytes from normal, but the polynuclears were decreased at all times. The eosinophilia, although slightly increased during the day, rose to a maximum at the time when the embryos were most numerous, reaching 20.5.

Following operation the red cells and hæmoglobin remained unchanged. The white cells showed no increase. The differential count showed that the lymphocytes had dropped almost to normal; that the mononuclear cells were normal, and that the polynuclears had risen and the eosinophiles fallen almost to normal percentages.

Prophylaxis.—There seems to be no doubt that filariasis is transmitted through the mosquito; therefore, any prophylactic measures against infection must depend upon protection from mosquitoes.

By special conditions for breeding the *Anopheles* may be annihilated from a locality. The *Culices* breed more readily, and select any collection of water for this purpose.

The protection of stored water from the insects and the frequent emptying of vessels containing water, so as not to allow sufficient time for larvæ to mature, and employing only that water which is freshly filtered, are the only means for the prevention of infection from this source. Mosquito-nets should be worn as a safeguard when in filarial districts. Individuals infected with filariæ are a constant source of danger to the community.

Treatment.—So far as is known, the embryos are not

harmful, and the treatment is therefore directed toward killing or removing the parent worm.

Medical Treatment.—Numerous drugs have been employed in attempting to cure filarial disease. Flint recommends methylene blue, 0.12 every four hours, and believes that he cured a case of chyluria by this means. Zellweger claims to have produced good results in five cases of lymph scrotum and chyluria with this drug, while Henry found methylene blue absolutely inefficacious. Thymol, benzoic acid, benzoate of soda, and boric acid have also been supposed to have a beneficial effect. Scheube claims to have killed the parasite by administering picric-nitrate of potash.

The most commonly employed drug is quinine, and although weak solutions will kill the embryo outside of the body, it seems to have no effect whatever upon them while in the circulation.

Recently Wherry and McDill exposed the back of a patient suffering with hæmatochyluria to the "X-rays." After the exposure the embryos were found to be in no way affected.

In hæmatochyluria some relief of symptoms has been gained by bladder irrigation with mercurial chloride, 1-10,000, boric acid, and other solutions of mild antiseptics. When the bleeding is considerable adrenalin chloride has been injected into the bladder, and given by mouth, with good results.

Medical treatment must be considered to be of use only to palliate the symptoms arising as manifestations of the disease itself.

Operative Treatment to be anything more than symptomatic and palliative must be directed toward removing the parent worm. The thoracic duct, pelvic and abdominal lymphatics are not readily accessible, and when the parent filariæ are here situated the only form of treatment that can be employed is absolute rest, with the hips elevated to reduce the hydrostatic pressure, and a light diet with restricted fats. Diuretics and cathartics are of value in reducing the tension within the lymphatics.

However, even if the adult worms are so situated and the lymph stasis has produced dilated lymph-glands, lymph scrotum, chylocele, or other external evidences of the disease which are annoying to the patient, operative treatment, as a palliative measure, has been followed by marked beneficial results. If, on the other hand, the local condition harbors the parent filariæ, an operation removing the lymph-vessels, and the adult filariæ Bancrofti, will be curative.

Three distinct objections have been put forth against operation for the removal of lymphatic varices, and lymph adenocèles: First, that such operations are unscientific in principle, because only a portion of the varix is removed and the obstruction in the lymph circulation still remains. Second, that persistent lymphorrhagia and lymphatic fistulæ follow. Third, that such operations are liable to result in septic infection or erysipelas.

Operative experience has shown, however, that the varices are often local and can be entirely removed; that the patient may be cured of his symptoms even though the parent worms are not demonstrated in the excised mass; and that when the parent filariæ themselves are removed the patient is truly cured.

Maitland, who has had considerable operative experience with this disease, and who is familiar with the experiences of other surgeons in Madras and elsewhere, states that he has never known or heard of a lymphorrhagia or lymphatic fistula resulting from operation. Maitland states also that he has not seen or heard of a fatality by septic inflammation or erysipelas resulting from operation. He further states that a tight dressing placed over the wound causes the lymphatic channel to become sealed, and oozing does not take place in a greater degree than would from any operation wound.

Experience has proven that the suffering produced by the constantly recurring attacks of pain, erysipeloid inflammations and constitutional symptoms, has been relieved by removing varices which are accessible.

Following are brief outlines of the cases which have been operated upon:

PRIMROSE records a case of a man suffering from filariasis, upon whom he operated for lymphscrotum. In the excised tissue an adult filaria and several fragments were found. Twenty-four days after operation embryos were abundant in the blood; which showed that all the adult filariæ had not been removed. Forty-six days later the patient had an attack of lymphangitis in the neck. A circumscribed swelling developed, which was opened ten days later and sloughing tissue was removed. No adult worm was detected. Sixty-seven days after the second operation all embryos had disappeared from the blood.

MANSON expressed the opinion regarding this case that the first operation upon the lymphscrotum was not the one which cured the patient, but that the lymphangitis in the neck was probably the site of the remaining parent worm.

MR. H. J. STILES operated upon varicose groin-glands in a case in which Gullard studied the blood. No mention, however, as to the final outcome was made.

BROWN operated upon a case in which there was a straw-colored fluid in the tunica vaginalis. The testicle and the lower third of the vas deferens were removed. A small nodule was found situated in the testicle just under the epididymis. It had a compact fibrous periphery, and in the center was a yellowish-white, semi-fluid material. Smears were stained for tubercle bacilli, but none were found; instead, however, larvæ of the filaria sanguinis hominis were discovered.

MAITLAND reports three cases upon which he has operated with good results. First, a case of lymph-gland of the right groin. The entire mass was removed. The patient had remained well at a period four years after operation. Second, the case was of an individual with a large lymphatic varix in the right femoral region. The result nine years after operation was entirely satisfactory, and Maitland quotes portions of the patient's testimony, one sentence of which is as follows: "It is beyond description to write of the benefit of the operation," Nine years after the operation the patient was again attacked by the disease, the lymphatic obstruction being in the inter-abdominal vessels. The third case was one with a large lymphatic varix in the right groin, and a smaller one in the left groin. The mass in the right groin was removed, and suppuration occurred in the wound. One month after operation no filariæ could be demonstrated in the blood. The year of this operation was 1894. Maitland's report was in 1902, and in that time, he stated, the patient had remained well, and the varices in the left groin had caused no trouble.

FLYNN removed a varicose tumor of the left spermatic cord, leaving the testicle and vas deferens. The parent worms were not found, but the embryos disappeared from the blood, and it is believed that they must have escaped detection in the mass. Flynn has done partial excisions of the tunica vaginalis in five patients, and, as he expresses it "each patient considers himself cured."

LOTHEROP removed a varicose spermatic cord, together with the

testicle and tunica vaginalis. Nine parent worms were found, and although filarial embryos were persistent in the blood the patient was relieved of his symptoms.

GODLEE, following the suggestion of Manson, cut down upon a lymph varix in the right groin, and anastomosed a dilated lymphatic vessel with a tributary of the internal saphenous vein. The result was that the lower part of the swelling disappeared. The upper part remained, however, and a month later he anastomosed one of the dilated lymphatic vessels of the cord with one of the spermatic veins. The swelling disappeared and has remained so. Manson and Godlee believe that the obstruction to the thoracic duct was opposite the lymphatics accompanying the spermatic vessels, and that although the obstruction still remains there is no regurgitation of chyle.

GODLEE operated upon another case with large swellings in both groins. the swelling in the right groin was exposed, and one of the lymphatics anastomosed with a vein. At a second operation the swelling in the left groin was exposed, partially removed, and a lymphatic was anastomosed with a tributary of the internal saphenous vein. A portion of the tumor in the right thigh was removed at the same time. There was considerable oozing of chyle and lymph subsequently, but the wound healed rapidly. The improvement was not so marked as in his previous case.

The cases of filariasis treated surgically are comparatively few. The relatively large number treated medically, and the little benefit so obtained, leads one to hope that more cases may receive surgical treatment. Even though the parent worms are not found, as in the writer's case, they may be retained within the diseased mass and escape detection, the embryos disappearing from the blood, and the individual remaining free from his symptoms.

On the other hand, when the parent filariæ are known to be left alleviation of the symptoms has followed by overcoming the stasis and regurgitation of chyle.

It is not without interest to note that there are five cases which committed suicide while under observation, and that another attempted suicide, but failed.

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